

# MSK Trauma Imaging: Language of Extremity Fractures



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## Overview

### Systematic Approach

(ABCDE'S)<sup>2</sup> in MSK Imaging

I dentify the abnormality (*Recognize* injury)  
D efine the appearance (be descriptive)

C ategorize (when able); patterns, grades  
D ifferential Diagnosis

### Trauma evaluation:

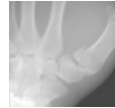
Descriptive terms, considerations

Adults, pediatrics  
Superior to Inferior



### Trauma to recognize

Things you (and your patient) don't want to miss  
Some subtle, some invisible (secondary signs)



### Summary

Mnemonics  
Overview  
Questions

References

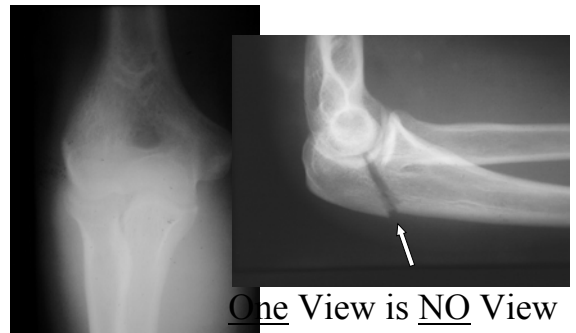


## Recognize the Injury Rule #1

Radiograph where it hurts or where it is  
deformed



## Recognize the Injury: Rule #2 Two Orthogonal Views at a Minimum



One View is NO View

## Recognize the Injury: Rule #3

Long Bones: Need to See the Joints at Both Ends



## Back to the Basics: Systematic Approach



- Trauma ABCDE's
  - Airway, Breathing, Circulation
    - Disability (neuro, AVPU), Extremities
  - Cervical Spine Stabilized before Airway
    - i.e. jaw-thrust in unconscious or suspected injury
  - Evaluate extremities after stabilizing ABC's
- Radiologic triage: prioritize multiple cases

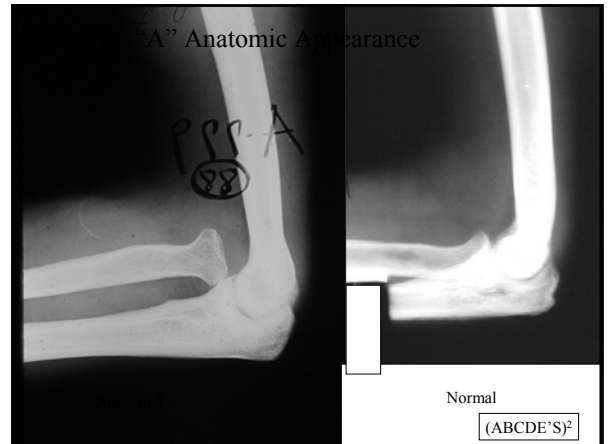
## (ABCDE'S)<sup>2</sup> in MSK Imaging

- |                                    |                                  |
|------------------------------------|----------------------------------|
| A = Anatomic appearance            | A = Alignment, Asymmetry         |
| B = Bone Density                   | B = Bone mineralization          |
| C = Cartilage (joint, disk spaces) | C = Contours, Characteristics    |
| D = Distribution                   | D = Deformity (trauma, acquired) |
| E = Erosions                       | E = Extent                       |
| S = Soft tissues                   | S = Swelling                     |

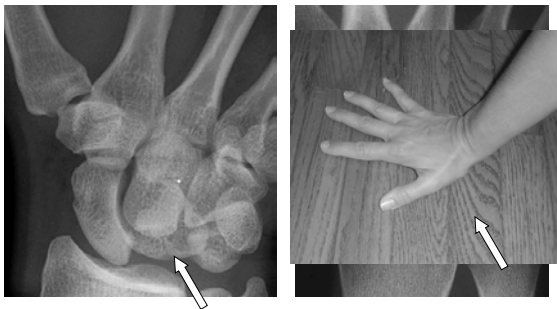


"Checklist"

System	Findings
Neck	Alignment, Asymmetry, Bone mineralization, Contours, Characteristics, Deformity (trauma, acquired), Extent, Erosions, Swelling
Shoulder	Alignment, Asymmetry, Bone mineralization, Contours, Characteristics, Deformity (trauma, acquired), Extent, Erosions, Swelling
Elbow	Alignment, Asymmetry, Bone mineralization, Contours, Characteristics, Deformity (trauma, acquired), Extent, Erosions, Swelling
Wrist	Alignment, Asymmetry, Bone mineralization, Contours, Characteristics, Deformity (trauma, acquired), Extent, Erosions, Swelling
Hand	Alignment, Asymmetry, Bone mineralization, Contours, Characteristics, Deformity (trauma, acquired), Extent, Erosions, Swelling
Foot	Alignment, Asymmetry, Bone mineralization, Contours, Characteristics, Deformity (trauma, acquired), Extent, Erosions, Swelling

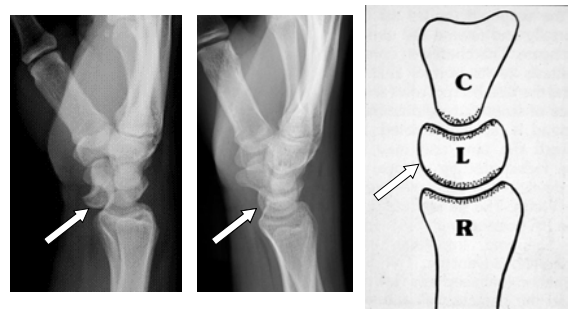


## "A" Anatomic Appearance

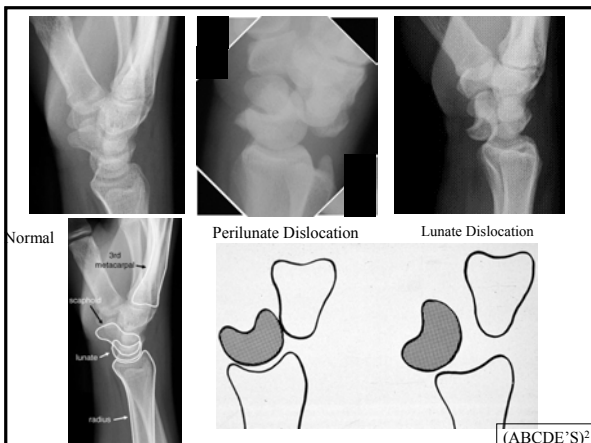


(ABCDE'S)<sup>2</sup>

## "A" Anatomic Appearance

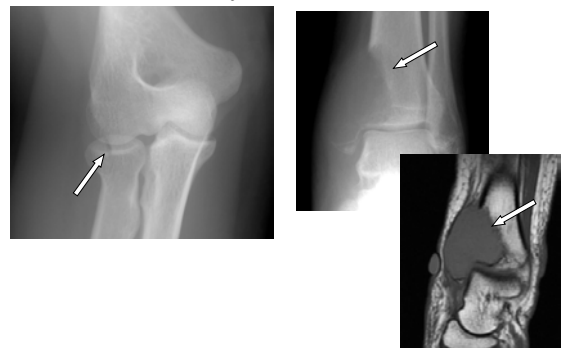


(ABCDE'S)<sup>2</sup>



(ABCDE'S)<sup>2</sup>

## "B" Bony Mineralization



(ABCDE'S)<sup>2</sup>

### "C" Cartilage "Joint Space"



(ABCDE'S)<sup>2</sup>

### "C" Cartilage "Joint Space"



(ABCDE'S)<sup>2</sup>

### "C" Contours, Characteristics

Disruption of edge, intra-articular



(ABCDE'S)<sup>2</sup>

### "D" Deformity



(ABCDE'S)<sup>2</sup>

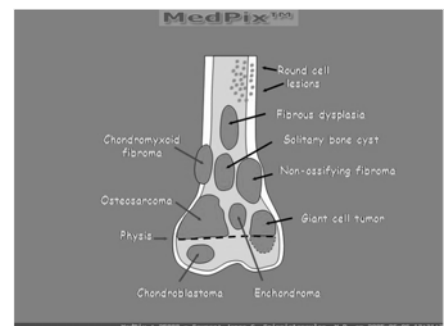
### Distribution

Multiple ribs  
Various healing stages  
(Non-accidental trauma)



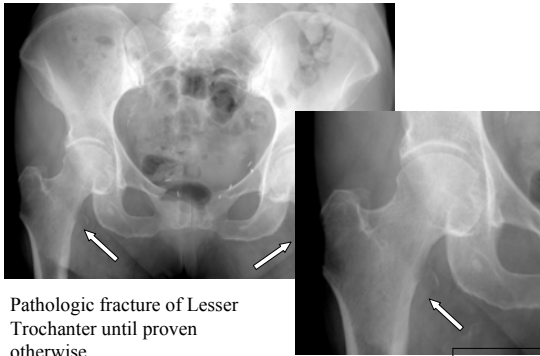
(ABCDE'S)<sup>2</sup>

### "E" Erosions, Extent



(ABCDE'S)<sup>2</sup>

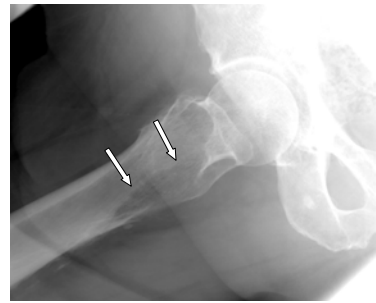
## “E” Erosions, Extent



Pathologic fracture of Lesser Trochanter until proven otherwise

(ABCDE'S)<sup>2</sup>

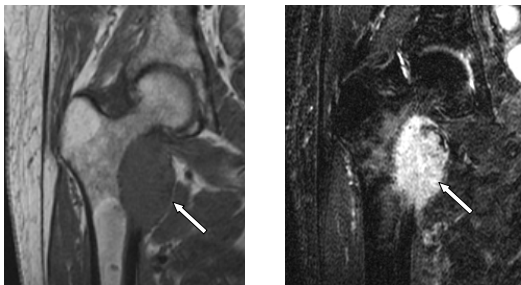
## Lesser Trochanter



Large lytic lesion in intertrochanteric region of femur

(ABCDE'S)<sup>2</sup>

## Lesser Trochanter

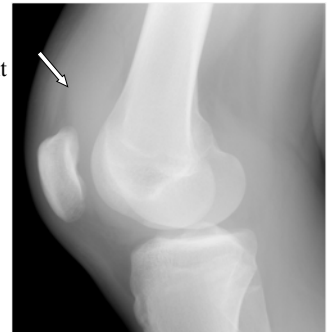


(ABCDE'S)<sup>2</sup>

## “S” Soft Tissues

Joint effusion

= internal derangement



(ABCDE'S)<sup>2</sup>

## “S” Swelling



(ABCDE'S)<sup>2</sup>

## Describing MSK Trauma

- |   |  |
|---|--|
| <ul style="list-style-type: none"> <li>• Integrity of Skin                             <ul style="list-style-type: none"> <li>– Open or Closed</li> </ul> </li> <li>• Severity of Fracture                             <ul style="list-style-type: none"> <li>– Incomplete/Complete</li> <li>– Comminuted</li> </ul> </li> <li>• Fracture Line                             <ul style="list-style-type: none"> <li>– Transverse, oblique, spiral</li> </ul> </li> <li>• Location</li> <li>• Avulsion, distraction</li> </ul> | <ul style="list-style-type: none"> <li>• Separation/Overlap of Fragments</li> <li>• Displacement                             <ul style="list-style-type: none"> <li>– Alignment/Position</li> </ul> </li> <li>• Relationship to Joint/Growth Plate</li> <li>• Integrity of Underlying Bone                             <ul style="list-style-type: none"> <li>– Pathologic fracture</li> </ul> </li> </ul> |
|---|--|



## Integrity of Skin

- Open
  - Surgical emergency – washout/debridement
  - Open fracture → open surgical reduction
  - Gas in soft tissues/bone thru skin
- Closed
  - Overlying skin intact
- Old terminology
  - Simple
  - Compound



## Crush Injury to Distal Phalynx



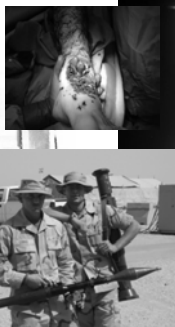
Is the nail bed intact?

Open

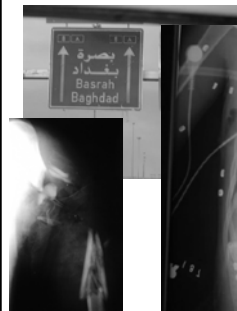
## Blast, shrapnel, RPG



"Those bullet holes are something new, aren't they?"

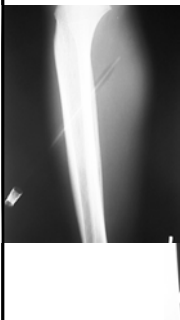


## Blast Injury



Open

## Penetrating Injuries



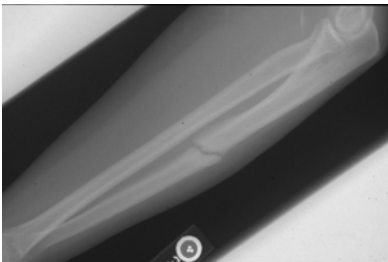
Open

## Vascular Considerations



## Fracture

- A complete or incomplete break in the continuity of bone or cartilage



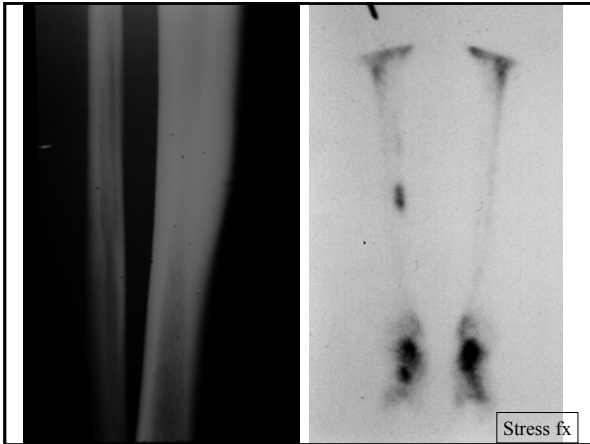
## Severity of Fracture

- Incomplete – only one side of cortex
  - Usually in children
    - Greenstick – break on convex side
    - Torus – buckle
  - Adults:
    - Stress fx: abnormal stress to normal bone
    - Insufficiency: normal stress to abnormal bone
- Complete – complete disruption of cortex

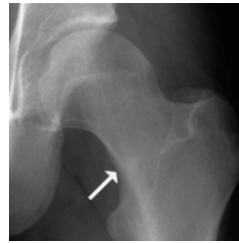
## Stress Fracture

- Excess or abnormal stress applied to normal bone
- Resorption exceeds repair
- Bone scan or MR are more sensitive for detection of early stress fracture
- Insufficiency fracture
  - Normal stress to osteoporotic bone





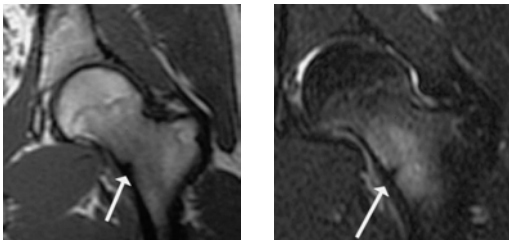
## Stress Fracture of Hip



19 y.o. basic trainee presents with pain in left hip while running  
 -Plain film: demonstrates sclerotic line in femoral neck perpendicular to normal trabeculae

Stress fx

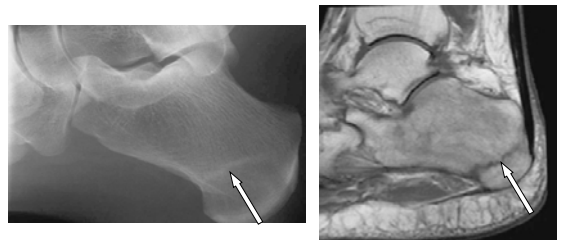
## Stress Fracture of Hip



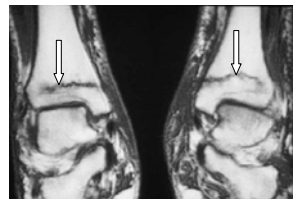
-MRI: demonstrates black line on all pulse sequences  
 -Line does not traverse entire width of femoral neck  
 -Surrounding edema is present

Stress fx

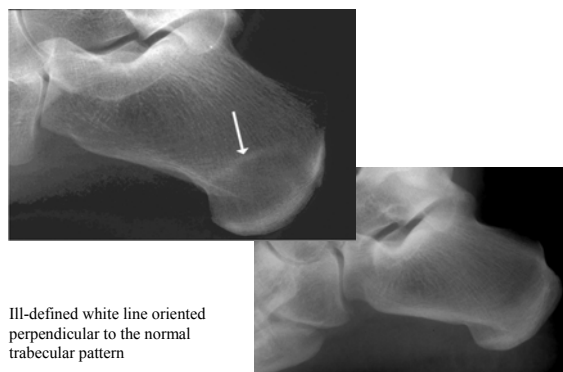
Incomplete fracture in adult is usually a stress fracture



## Insufficiency Fractures



-54 y.o. women with history of breast carcinoma  
 -On Tamoxifen  
 -Bilateral ankle pain after trip to Hawaii

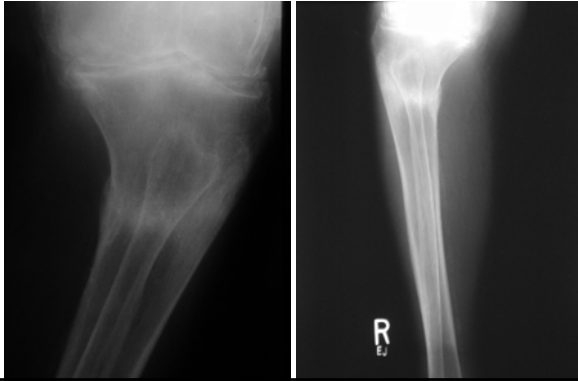


Ill-defined white line oriented perpendicular to the normal trabecular pattern

Normal trabecular pattern

Stress fx

## Insufficiency Fracture



## Complete Fracture



## Fracture Line Orientation, Location

- Transverse
- Oblique
- Spiral

Location  
What 1/3?

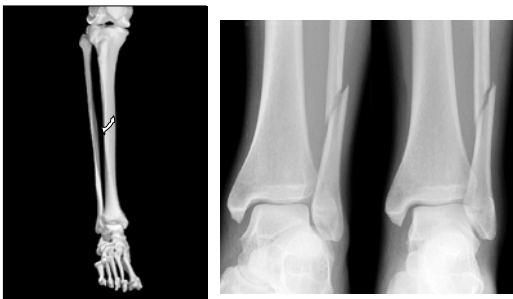


## Transverse



Orientation/ location

## Oblique



Orientation/ location

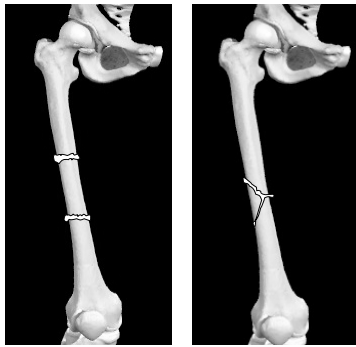
## Spiral



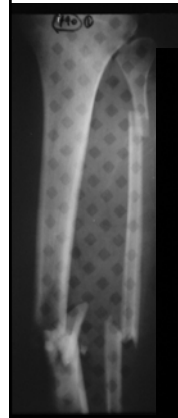
Orientation/ location

## Comminuted Fracture

- More than two fragments
  - Segmental
  - Butterfly



Orientation/ location

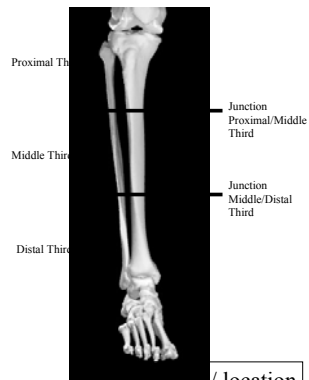


Comminuted

Orientation/ location

## Location

- Long bones: divide diaphysis of into thirds



Orientation/ location

## Location

- Anatomic description for other areas
  - Humeral head
  - Tibial plateau
  - Waist of scaphoid
  - Femoral condyle
  - Femoral neck
  - Intertrochanteric

Orientation/ location

## Location

- Anatomic description for other areas
  - Humeral head
  - Tibial plateau
  - Waist of scaphoid
  - Femoral condyle
  - Femoral neck
  - Intertrochanteric



Orientation/ location

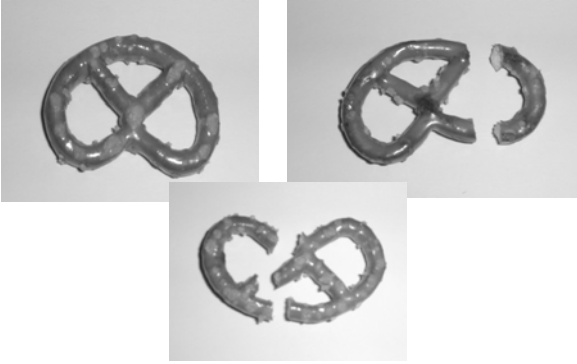
## Location

- Anatomic description for other areas
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  - Femoral neck
  - Intertrochanteric



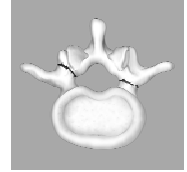
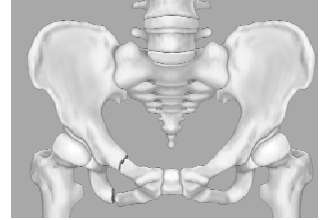
Orientation/ location

## Osseous Rings



## Osseous Rings

- Pelvis
- Mandible
- Radius/ulna
- Tibia/fibula
- Post elements spine
- Orbit
- Maxillary Sinus



## Ulna/Radius, Tibia/Fibula

### Act Like Ringed Structures

-If one bone  
fractured



-Look for fracture or  
dislocation of other bone



Osseous Rings



## Ulna/Radius

## Tibia/Fibula

### Act Like Ringed Structures

-If one bone fractured



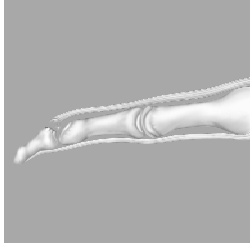
-Look for fracture or dislocation of  
other bone



Osseous Rings

## Separation/Overlap of Fragments

- Distraction
  - Separation of fragments
    - Tendon
    - Traction
    - Interposed soft tissue



## Mallet Finger

- Sudden resisted flexion of DIP joint
- Finger jammed or distal tip hit with a ball



Separation/Overlap

## Avulsion Fracture of Flexor Digitorum



Separation/Overlap

## Overriding fragments

- Describe in cm



Separation/Overlap

## Separation/Overlap of Fragments

- Impaction
  - Fragments driven into each other
- Depression
  - Cortical meets cancellous
- Compression
  - Crushing of trabecular bone



Separation/Overlap

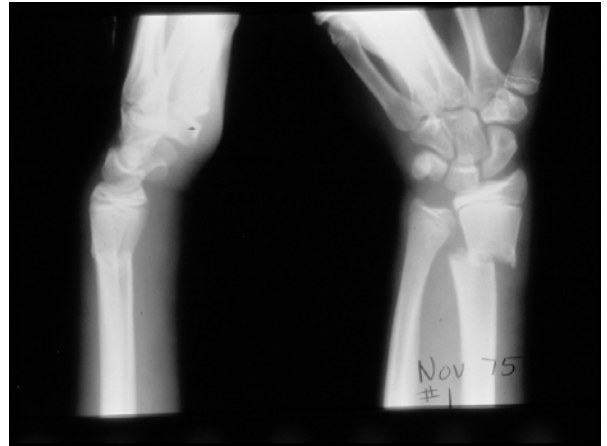


Lateral tibial plateau displaced downward

Separation/Overlap

## Position (Displacement)

- Description of fragments relative to normal
- Assume proximal fragment is normal
- Describe distal fragment relative to prox
  - Use shaft width as a guide
- Use terms anterior, posterior, medial or lateral



## Angulation

- Relation of long axes of one fragment to another
- Angulation is independent of displacement
- Assume proximal fragment is normal
- Describe direction of fracture apex
  - or
- Describe direction distal fragment

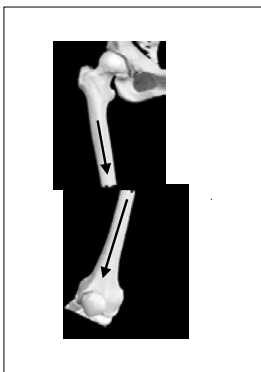
### Fracture Description



### Angulation

1. Assume proximal fragment is normal
2. Draw the axes of the two fragments

### Fracture Description

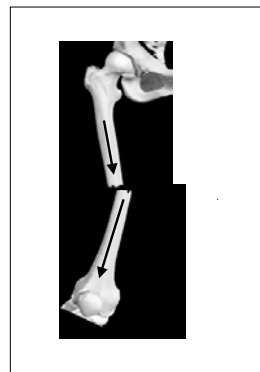


### Displacement

Quantify and give direction of displacement of distal fragment  
Use "shaft-width" to Quantify

- Distal fragment displaced 1 shaft-width medially
- Apex medial angulation

### Fracture Description



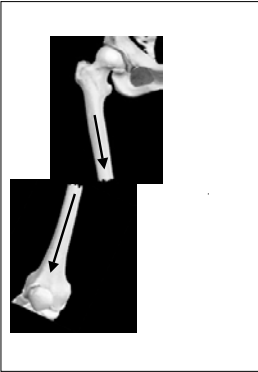
### Displacement

Quantify and give direction of displacement of distal fragment

- Distal fragment displaced 1/2 shaft-width medially
- Apex medial angulation



### Fracture Description

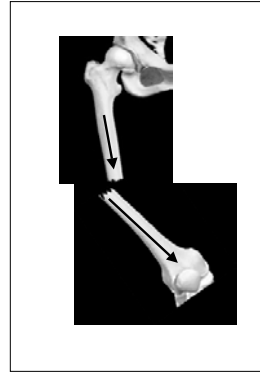


### Displacement

Quantify and give direction of displacement of distal fragment

- Distal fragment displaced 2 shaft-widths laterally
- Apex medial angulation

### Fracture Description

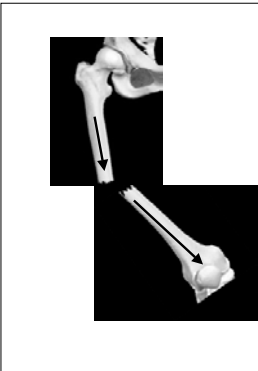


### Displacement

Quantify and give direction of displacement of distal fragment

- Distal fragment displaced 1 shaft-widths laterally
- Apex lateral angulation

### Fracture Description

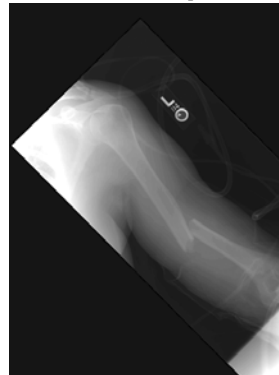


### Displacement

Quantify and give direction of displacement of distal fragment

- Distal fragment displaced 1 shaft-width medially
- Apex lateral angulation

### Fracture Description



- Distal fragment displaced 1 shaft-width laterally
- 20° of apex medial angulation at fracture site
- 1 cm of shortening (overlap) of fracture fragments

## Integrity of Underlying Bone

- Underlying bone is abnormal
- Diagnosis may be benign or malignant
- History is often minimal trauma
  - When fractured, either pathologic or insufficiency

## Pathologic Fracture

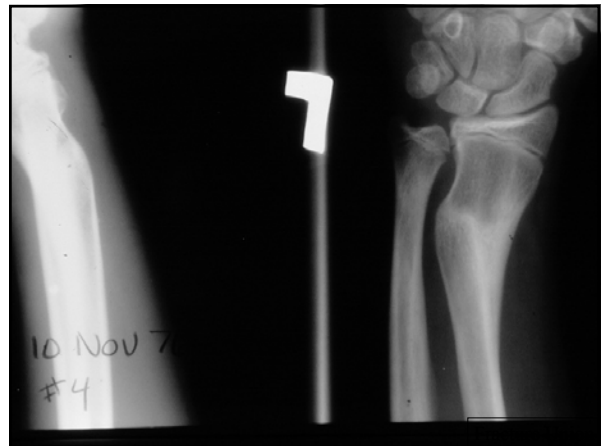
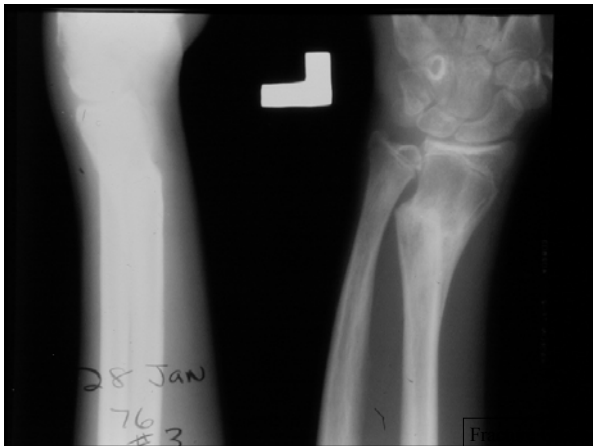
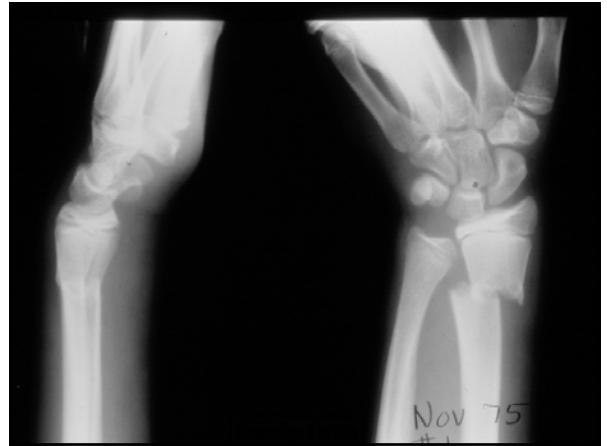
Expansile lucent area  
Large, metaphyseal  
Fallen fragment  
Narrow transition zone  
Simple bone cyst

MedPix™



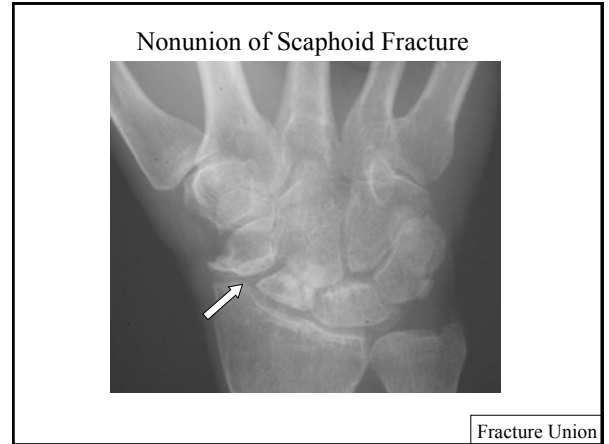
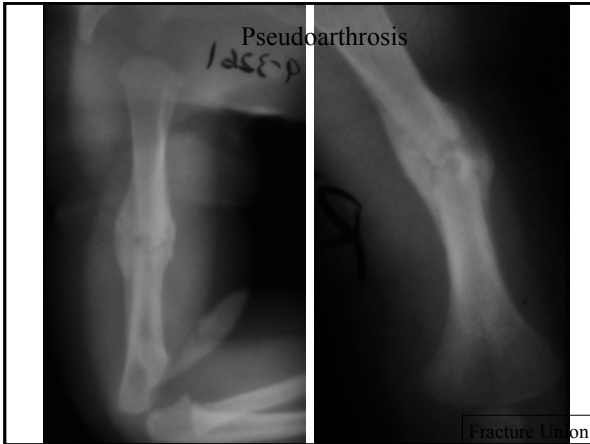
## Fracture Union Terminology

- Callus – new bone formed at fracture site
- Remodeling – reforming of callus along lines of stress to approximate normal contour
- Delayed Union – Fracture fails to heal in usual time but will heal if cause of delayed healing is corrected



## More Fracture Union Terminology

- Non-union – failure of fracture fragments to unite and healing process has stopped
- Pseudoarthrosis – Bursal sac and fibrous tissue that develops at site of non-union
- Malunion – fracture fragments have healed with angular or rotational deformity that impairs function



### Avulsion Fracture

- Fracture involving the attachment site of a ligament or tendon insertion

### Skier's Thumb Injury

Disrupt Ulnar Collateral Ligament

Avulsion

### Anatomy: 1<sup>st</sup> Metacarpal Phalangeal Joint

Ulnar Collateral Ligament

Adductor Pollicis

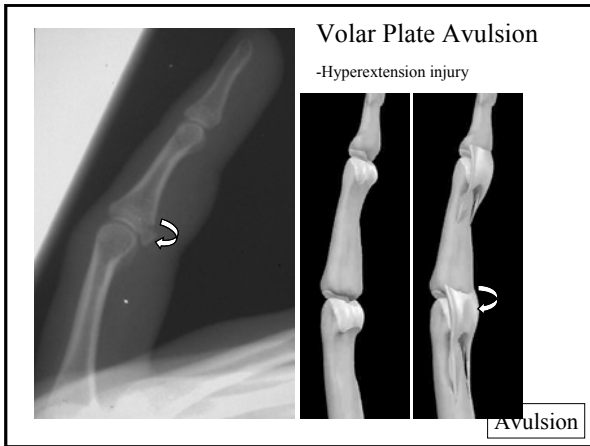
Avulsion

### Stener Lesion

-UCL: retract and displaces superficial to the adductor aponeurosis

-Requires surgical repair: leads to instability and early arthrosis

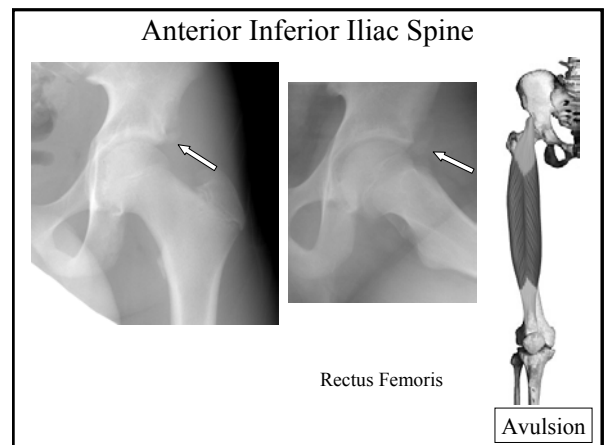
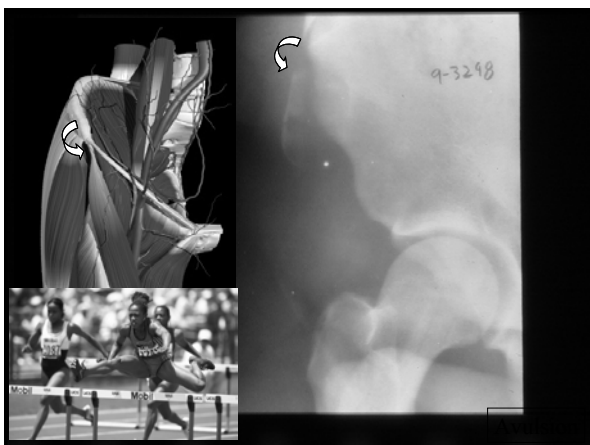
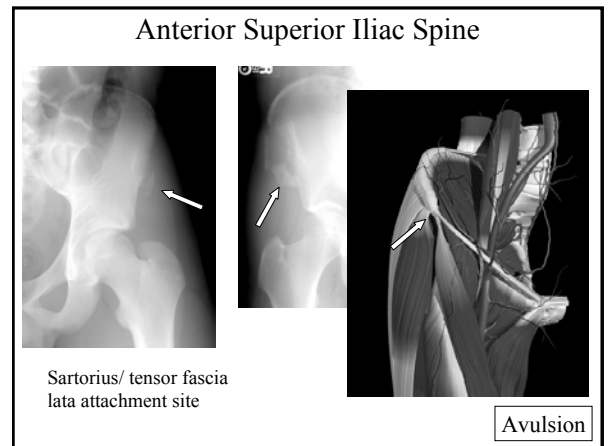
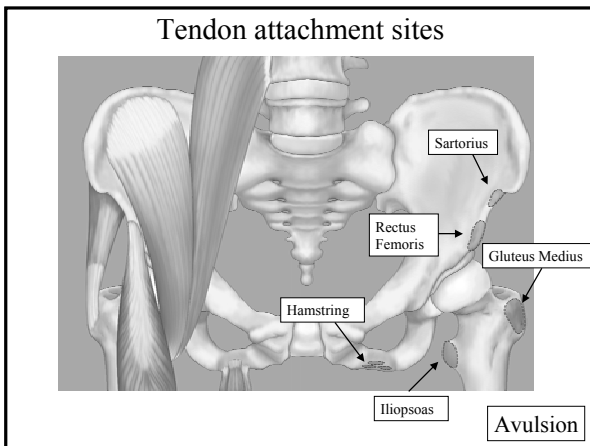
Avulsion

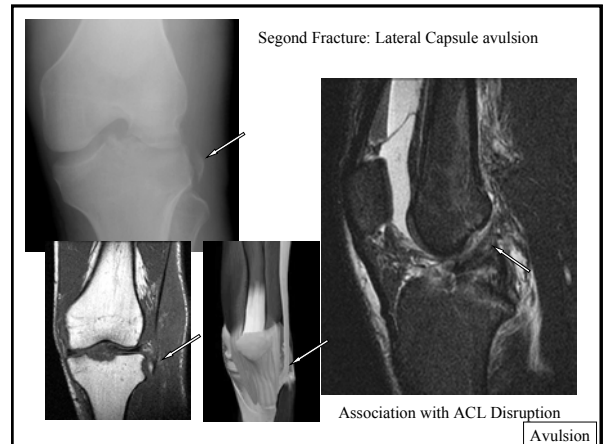
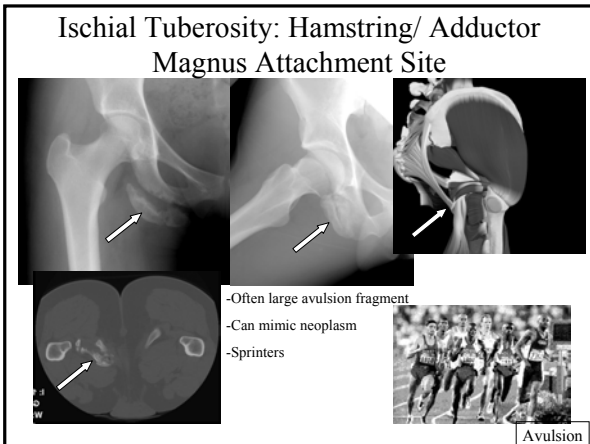
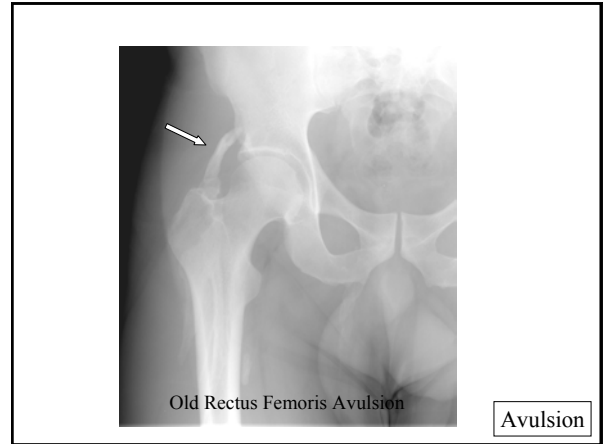


### Apophyseal Avulsions

- Result from violent muscular contraction
- Typically seen in adolescent athletes
- Equivalent to a muscle pull in a mature athlete
- Sprinters, long jumpers, cheerleaders, hurdlers, gymnasts
- Pelvis: common location in adolescent runners

Avulsion

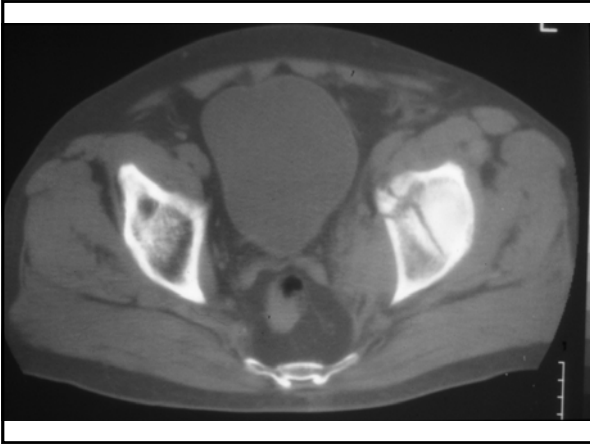




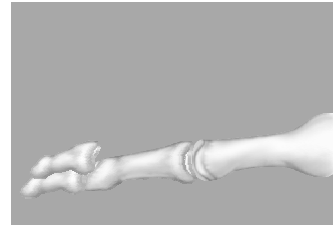
## Intra-articular Fracture

- Fracture involves the joint surface of bone
- Often present with effusion
- Increased risk of post-traumatic osteoarthritis
- May involve bone and/or cartilage
- May require advanced imaging (CT or MR) to adequately characterize

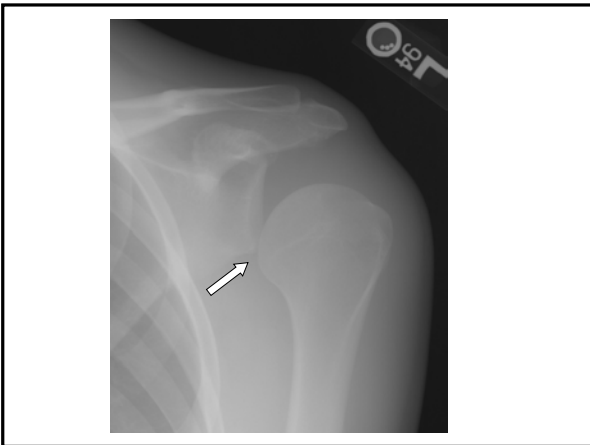




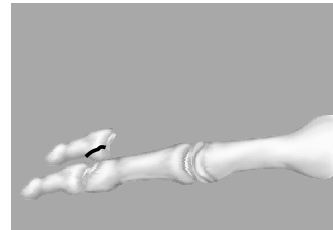
## Subluxation



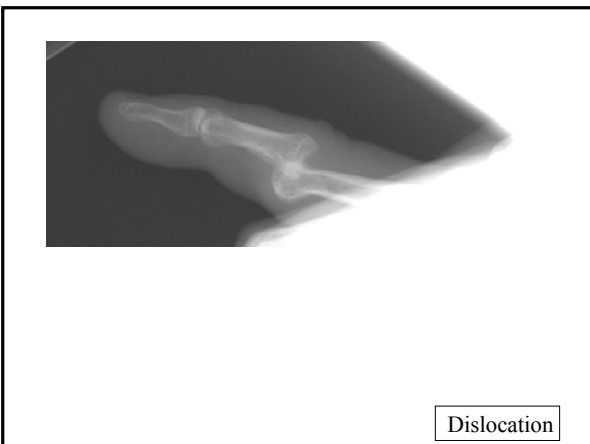
- Abnormal relationship between ends of a joint with some contact of the articular surfaces
- Incomplete dislocation



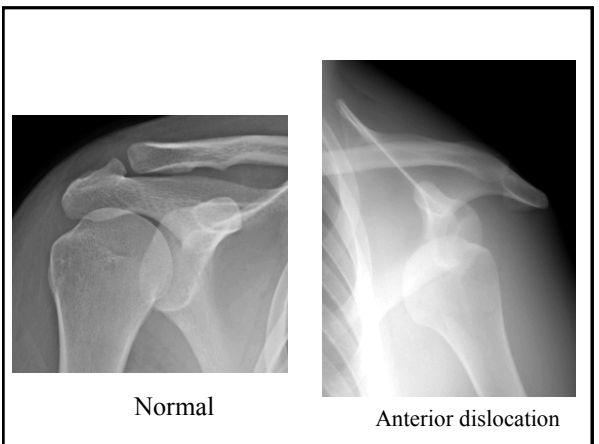
## Dislocation



- Complete separation of articular surfaces
- May be associated with a fracture
  - Fracture dislocation



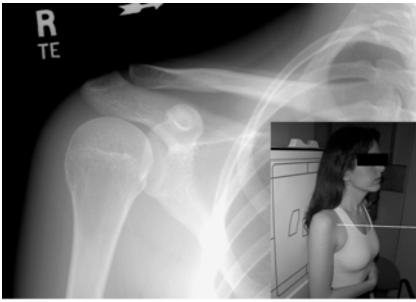
Dislocation



Normal

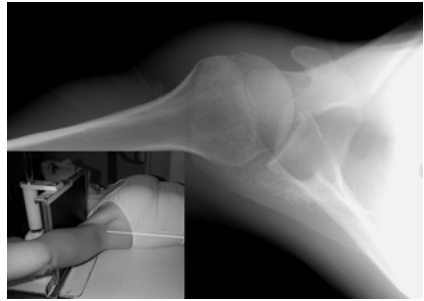
Anterior dislocation

## Imaging of Glenohumeral Joint



-Standard AP view is oblique to the GH joint

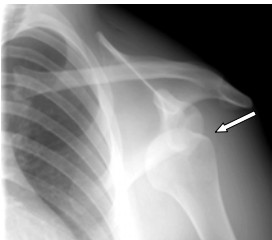
## Imaging of Glenohumeral Joint



-Axillary view (arm does not need to be abducted this much)

-Evaluate for subluxation/ dislocation (if patient can do)

## Anterior Dislocation



-Mechanism: fall on outstretched arm

-X-ray: humeral head displaced anterior and medial

## Lesions Associated with Anterior Dislocation



-Occurs secondary to humeral head impaction against inferior glenoid rim

Hill Sachs Lesion

Dislocation

## Posterior Dislocation



-Very obvious on axillary view



-Dislocates straight posterior on AP view- sometimes difficult to detect



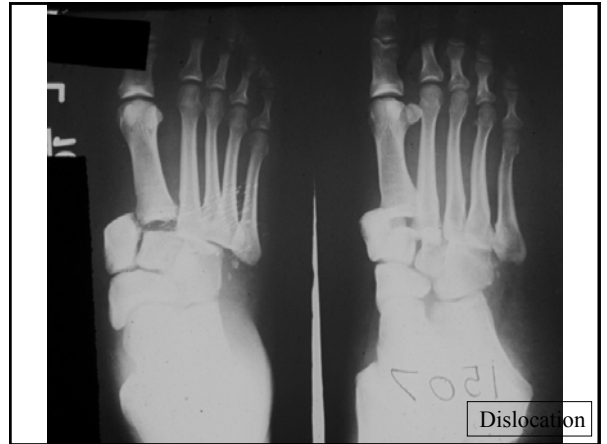
Dislocation

## Posterior Elbow Dislocation



-Direction of dislocation determined by the position of the distal bones

Dislocation



Dislocation

## Normal Anatomy of the Lisfranc Joint



Alignment



Lisfranc Ligament



## Diastasis

- Disruption of fibrocartilaginous joint
  - Pubic symphysis
  - Sacroiliac joint
  - Tibiofibular syndesmosis
  - Acromioclavicular joint



## Acromio-clavicular Joint Injuries



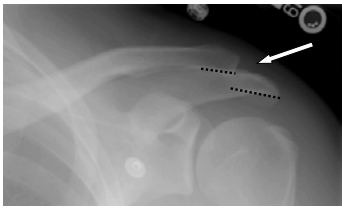
-Mechanism: fall on outer prominence of shoulder

-Grade I injury- mild strain of AC joint

Diastasis



## Acromio-clavicular Joint Injuries



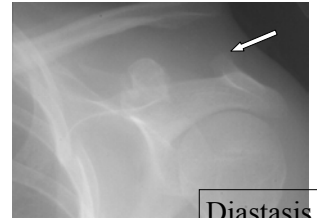
-Grade II injury- moderate strain

Diastasis

## Acromio-clavicular Joint Injuries



-Grade III injury- severe



Diastasis

## Distal Tib-Fib Joint



Diastasis



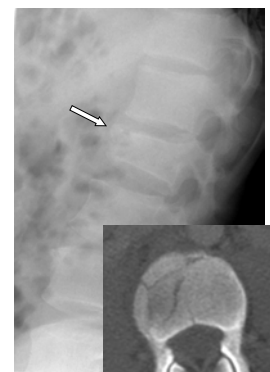
Diastasis

## Example cases

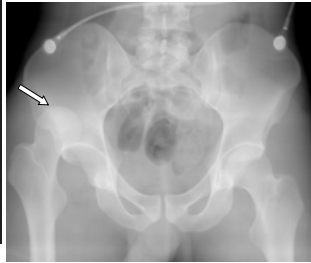
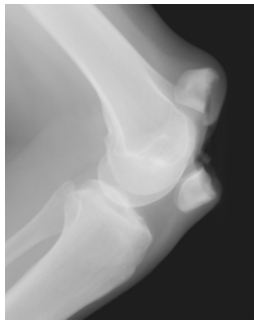
- Sum

Sum

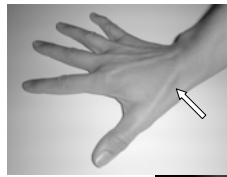
## Lover's Heel



### Dashboard Injury

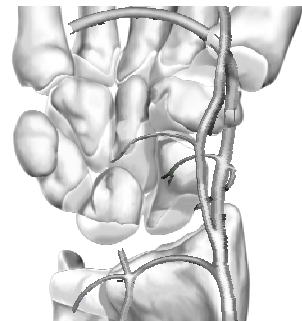


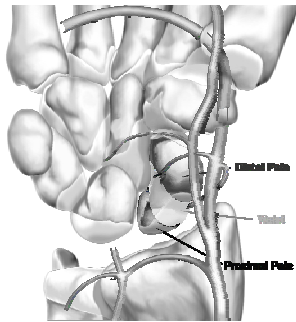
### Anatomic Snuff Box Tenderness



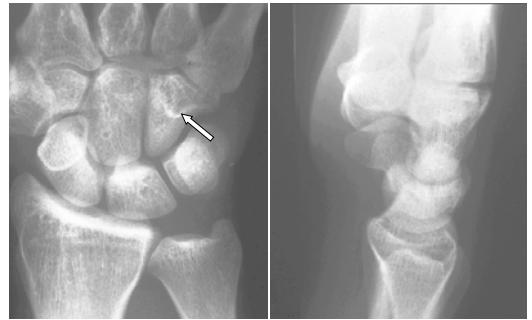
### Scaphoid Fracture

### Scaphoid View: Ulnar Deviation

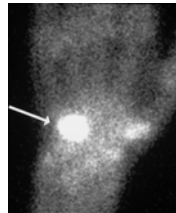
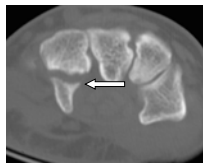
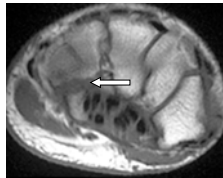
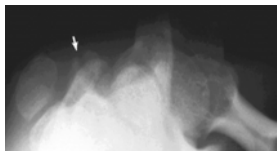




### Suspected Hamate Fracture- Point tenderness



### Carpal Tunnel View



### Persistent Lateral Ankle Pain Following Inversion Injury



-Fracture of the lateral talar process

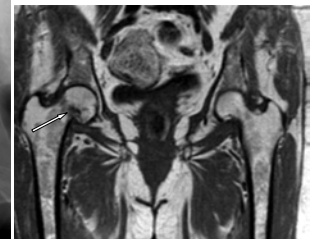
-Intraarticular fracture: 50% missed on initial plain film study

### Fracture of the Lateral Talar Process



- Subtalar joint
- Talofibular joint
- MR/CT to evaluate for radiographically occult fracture
- Surgical Lesion

### Occult Hip Fracture



18 y.o. airman basic with right hip pain

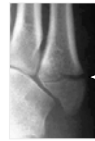


Bone scan confirms stress fracture of the medial hip

-Subtle perpendicular sclerotic line involving inferior medial femoral neck



Avulsion of Peroneus Brevis Tendon



Jones fracture more distal

## Pediatric Injuries

- Injuries occur in different pattern in growing bone
  - Greenstick, torus, plastic fractures
- Injury to physeal plate
  - Growth arrest and limb length discrepancy
- Injuries tend to heal faster

## Greenstick

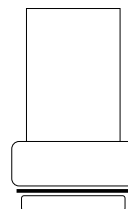


-Bowing with fracture on convex side

## Torus “Buckle” Fracture

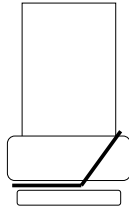


## Salter Harris Fracture Classification



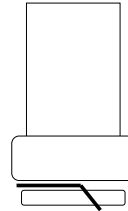
I – Through physeal plate  
–May need comparison views to recognize

## Salter Harris Fracture Classification



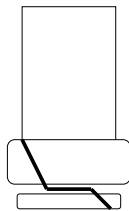
II – Physeal plate + metaphysis  
–Most common

## Salter Harris Fracture Classification



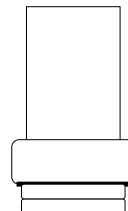
III – Physeal plate + epiphysis

## Salter Harris Fracture Classification



IV – Metaphysis, physeal plate, epiphysis

## Salter Harris Fracture Classification



V – Crush injury of physeal plate

## Salter-Harris classification

- I. S = Separation: Physis (growth plate)
- II. A = Above epiphysis
- III. L = Lower fragment: Physis/Epiphysis
- IV. T = Through both
- V. E = Epiphysis: Crushed Physis.
- VI. R = Really bad (rare, perichondral)

<http://rad.usuhs.mil/medpix/medpix.html?mode=single&recnum=4191&table=card&search=salter%20harris&search=salter%20harris#top>

## Salter II MedPix 7961





## Nonaccidental Trauma

- Must consider child abuse with unexplained injuries
- Specific injury patterns
  - Transverse fracture through long bone
  - Metaphyseal corner fractures
  - Metacarpal/metatarsal fractures
  - Posterior/anterolateral rib fractures
  - Multiple fractures in different stages of healing



## Summary

### SALTER

#### (ABCDE'S)<sup>2</sup> in MSK Imaging

A = Anatomic appearance	A = Alignment, Asymmetry
B = Bone Density	B = Bone mineralization
C = Cartilage (joint, disk spaces)	C = Contours, Characteristics
D = Distribution	D = Deformity (trauma, acquired)
E = Erosions	E = Extent
S = Soft tissues	S = Swelling

ID CD

I identify the abnormality (*Recognize* injury)  
D efine the appearance (be descriptive)

C ategorize (when able); patterns, grades  
D ifferential Diagnosis

